



The “CommTech” Methodology: A Demand-Driven Approach to Efficient, Productive and Measurable Technology Transfer

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Abstract

Market research sources were used to initially gather primary technological problems and needs data from non-aerospace companies in targeted industry sectors. The company-supplied information served as input data to activate or start-up an internal, phased match-making process. This process was based on technical-level relationship exploration followed by business-level agreement negotiations, and culminated with project management and execution. Space Act Agreements represented near-term outputs. Company product or process commercialization derived from Lewis support and measurable economic effects represented far-term outputs.

Introduction

In an era of shrinking high-risk private sector research and development expenditures there is an increasing dependence on government long-term technology development. Public to private technology transfer is steadily becoming a critical, strategic component of U.S. economic growth - both aerospace and non-aerospace.

NASA's mission is to develop aeronautical and space technologies and explore the frontiers of space. It is also NASA's mission to actively seek out non-aerospace industries and companies with technological problems or needs which might benefit from the transfer or application of its special, state-of-the-art aerospace capabilities. Where it is within NASA's capability, the agency will help companies eliminate shortages of knowledge or solutions, and possibly show the way to technological competitive or strategic advantage. In this regard, NASA plays an important role, along with other public sector technology producers, in contributing long-term, high risk R&D inputs that help stimulate investment and growth in the U.S. economy. With respect to non-aerospace technology transfer, the agency's Headquarters level "Commercial Development" program is evidence of its commitment to the broader economy.

At present, U.S. public sector R&D expenditures are on the order of \$60 billion. NASA's annual budget of about \$13 billion is a major fraction of the nation's total investment in R&D. NASA Lewis² receives about 5% or around \$0.7 billion of the NASA fraction to operate and fund its aeronautical and space power, propulsion, communications, basic materials, and microgravity fluids and combustion research and technology portfolio of research and development activities. Lewis scientists and engineers have built and maintained strong relationships³ with many aerospace companies in order to accomplish its aeronautical and space technology development mandate. Lewis has also continued to meet its parallel responsibility to transfer technology and expertise to non-aerospace companies in order to provide a larger return on the U.S. tax-payers' investment in aerospace technology.

¹ The author is a member of the NASA Lewis Research Center, Commercial Technology Office.

² Lewis presently has a population of about 1200 civil service and 1500 contractor scientists and engineers.

³ These relationships continue to be strengthened and redefined within the context of a new paradigm shift to a government/industry partnership mode in the face of severe budgetary constraints in Washington, D.C.

NASA Headquarters recently adopted a more proactive approach to carrying out its non-aerospace technology transfer mission. NASA Lewis subsequently developed the CommTech ("Commercial Technology" Consultants) program⁴ in accordance with the new agenda. CommTech was designed to pro-actively engage the private sector in a manner which compresses or minimizes public expenditures.

This paper presents a comprehensive review and assessment of the first (pilot) CommTech cycle - from its conception and initiation (in October, 1994) and planned activities extending to the present. The paper begins with an overview of the program's objective followed by an overview of the input/output model. A description of the core development and implementation strategy is presented next. This is followed by a presentation of the overall results of the implementation phases. Finally, the program's performance and comparative metrics are summarized and conclusions are drawn.

Goals and Objectives

The goal of this initial CommTech cycle was to demonstrate the potential low-cost/high productivity advantages of a demand-driven technology transfer model. If successful, then this "technology pull" approach could possibly complement or be a complete substitute for the "technology push" methods that had been employed throughout the agency to date. In practice, CommTech would apply a "company-led" strategy to systematically foster, track and measure the establishment, development and execution of 1 to 2-year relationships between non-aerospace companies and Lewis scientists and engineers.

In this regard, CommTech was conceived on the premise or understanding that:

- public to private technology transfer driven by private sector "market" demand (or pull) is potentially more efficient and productive than traditional technology "push" approaches;
- public to private, value-added technology transfer accrues best when public technologies/capabilities are applied to private sector problems/needs whose solutions are either limited or beyond current industry capabilities⁵;
- most companies that operate in non-aerospace industry sectors are generally unfamiliar with NASA technologies and are not in the NASA/Lewis communications loop; and
- public sector entities operate under general policy guidelines that prohibit the offering of services which are already supplied in the marketplace by private or privatized sources.

Based on all the above, CommTech was developed with the four-fold objective to:

1. Enhance Lewis' position as an accessible national technological resource for all tax-paying, "for-profit" companies in the United States regardless of location;

⁴ CommTech was created in response to a new NASA Headquarters policy outlined in the document entitled "Agenda for Change" in July, 1994. The agenda redefined the agency's responsibility to contribute to the commercial development of all sectors of the U.S. economy. It stated that NASA now considered the (non-aerospace) "Commercial Technology Mission" as "comparable in importance to those in aeronautics and space." The agenda was NASA's official response to Clinton White House (and Congressional) policy guidelines.

⁵ A good indicator of this would be the inability of a company to find private consultants or suppliers capable of solving special problems that might arise in the course of new product/process development.

2. Pro-actively identify companies with product/process technology development problems/needs that are beyond the commercial state-of-the-art, and which (to the best of a company's and Lewis' combined knowledge) have a low or zero potential of being met in the commercial supplier marketplace;
3. Increase the establishment of high quality non-aerospace technology transfer relationships via a controlled, structured process with clearly defined near and far-term deliverables, including clear program entry and exit-ways;
4. Broaden participation in the Agency's non-aerospace technology transfer mission by providing a clear structure which accommodates and supports the involvement of Lewis S&E's who have not had the opportunity to participate.

Overview of Input/Output Model

Figure 1 illustrates the basic eight-step (two staged - explained in the next section) process used to develop, start-up and operate the CommTech program.

(1) The NASA Lewis Commercial Technology Office⁶ released a request to determine product/process development problems/needs within specially targeted non-aerospace industry sectors (companies). Market research intermediaries were used. (2/3) The intermediaries conducted primary market surveys and (4) forwarded the results to the CTO (CommTech)

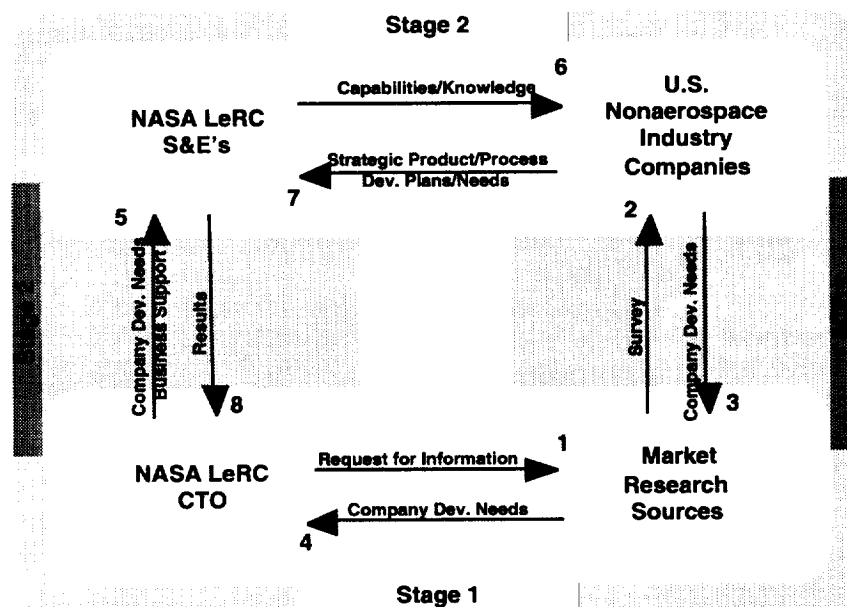


Figure 1. Input/output start-up and operation process model

program manager. Surveys were designed to produce respondents with a high "match potential." Care was taken to limit company expectations since it was known that the CommTech would only accommodate the interests of a few company respondents (depending on the size of both the companies' and Lewis S&E's responses) per cycle. (5) The survey results were then used as input data for an internal Lewis activity that identified individual scientists and engineers.

⁶ Originally called the "Office of Interagency and Industry programs, Technology Utilization Office."

(6) Interested S&E's admitted into the program proceeded to engage companies to further understand their needs. If requested, CommTech funds were used (at the discretion of participating S&E's) to demonstrate their capabilities to companies that were unfamiliar with Lewis. Every effort was made to avoid subsidizing private sector commercial interests. (7) If commercial potential was apparent, a company was expected to fund the transfer Space Act Agreement mechanism needed to realize that potential. (8) The expectation was that companies which participated would eventually produce and commercialize new (or improved) products or processes. These would incorporate enabling or unique, state-of-the-art support and/or technological contributions directly traceable to NASA Lewis.

Development and Implementation Strategy

CommTech development and implementation was conducted in two stages. Figure 2 portrays the two staged process schedule and all necessary activities and deliverables. Stage 1 consisted of six key activities and was directed toward the development, packaging and release of a program plan and a four-part compilation (appendix) of company needs. Stage 2 consisted of four phases with the ultimate objective to match specific company needs with Lewis capabilities and then establish and execute agreements.

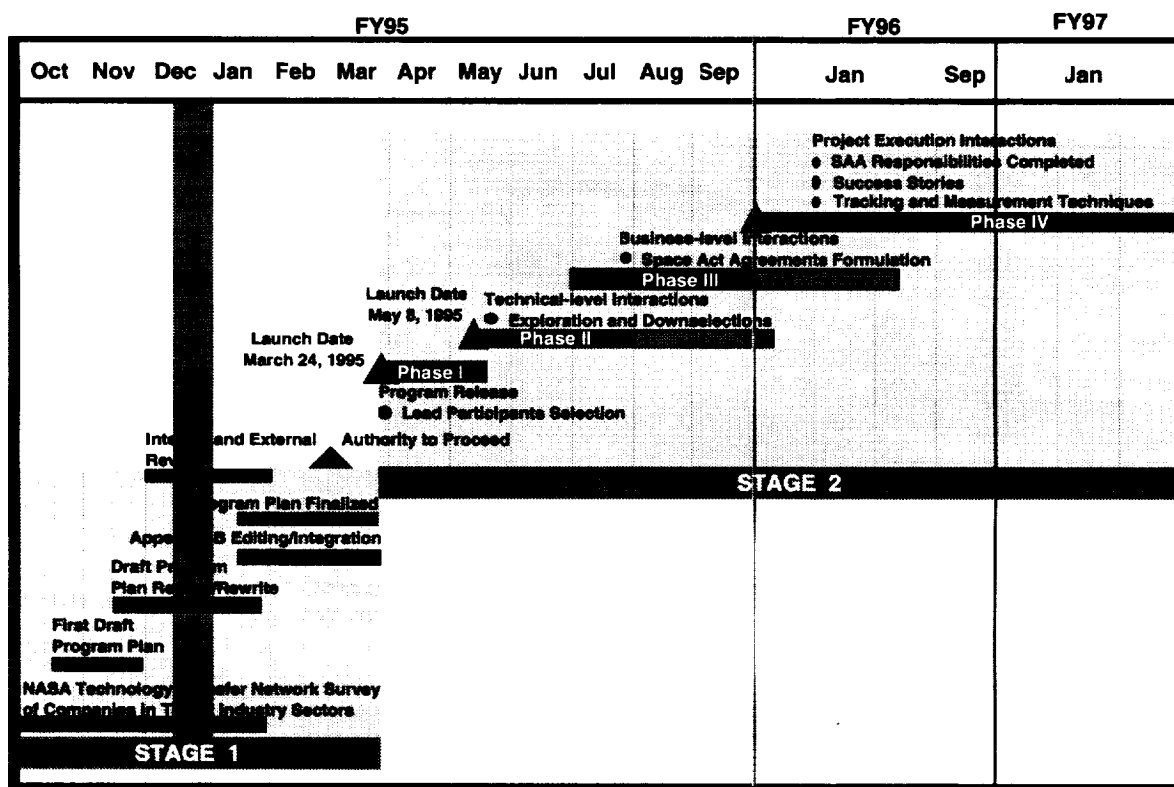


Figure 2: Two-staged development and implementation schedule.

The four stage 2 phases were entitled: I - Response and Participant Selection, II - Company Relationship Exploration, III - Relationship Definition and Agreement, and IV - Agreement Implementation and Execution. The estimated duration of both phases II and III had a built in slack of about 3 months considering the inherent uncertainty associated with accomplishing those objectives. Essentially, the rate at which a lead participant transitioned from phase II to phase III,

and then finally to phase IV, largely depended on a particular company's desired pace. In other words, each company controlled when phase transitions occurred. Lewis scientists and engineers did not. This was desirable since the program was fundamentally demand-driven or "company-led."

Program Development - Stage 1

In stage 1, the objective was to deliver a program plan and develop an appendix of company needs required to actuate phase I of stage 2. The program plan was designed to present a comprehensive, end-to-end description of the program and stimulate Lewis scientists and engineers' interest in participating. A three-part application was included within the plan for the convenience of any prospective Lewis participant (scientist or engineer) to apply for entry. The appendix of company needs (discussed below) enabled all interested scientists and engineers to apply and compete⁷ in phase I for entry into CommTech's key external interaction phases (II, III, and IV).

As a whole entity, NASA's Technology Transfer Network⁸ surveyed (exhibit 1) over several hundred companies to generate the raw data from which the appendix of company needs was produced. Each network member was asked to produce "primary," market research data on technology needs and other supporting business-type information on 45 companies from within each of their respective regions. In addition, both business- and technical-level points-of-contact were provided for each company. The network was responsive and largely successful, even though most (the RTTC's) had never previously operated in this mode. Because of this, the network's activity needed to be coordinated and guided by the CommTech program manager.

Specific industry sectors⁹ were targeted as required and the network had the latitude to select its own survey research method. Both written correspondence and telephone survey¹⁰ instruments were specially developed and employed. Written surveys provided a basic, comprehensive outline of NASA Lewis' areas of technology expertise. This helped companies make a preliminary assessments about Lewis S&E's advanced aerospace technologies/capabilities - and increased the "match potential." Companies then provided information about their special (proprietary or non-proprietary) product/process development problems or needs. They also indicated which Lewis technologies/capabilities areas they thought might best serve their interest (or be fruitful). All survey results were forwarded to the Lewis program manager (in early February, 1995) after a four month process. Following receipt of the raw data, a program plan and four-part appendix of company needs¹¹ (exhibit 2)¹² were finalized about a month later.

⁷ Phase I was competitive since a pool of limited funds (to be used only for technology/capability demonstrations) was to be allocated to each applicant selected to participate in phase II.

⁸ The seven NASA Technology Transfer Network members were: Far West Regional Technology Transfer Center, Mid-Continental RTTC, Southeast RTTC, Mid-West RTTC, Mid-Atlantic RTTC, Northeast RTTC, and Research Triangle Institute. NASA Lewis issued an informal "Request for Information" to each member of the network to initiate the process. At the time, all network members were contracted to NASA Headquarters to provide services to the whole agency.

⁹ Three main industry sectors were specifically targeted in this first cycle: Environmental, Surface Transportation, and Bioengineering. These industries were thought to have companies with high potential tech transfer synergies with Lewis technologies.

¹⁰ Network members constructed their own survey instrument. The program manager coordinated some of this activity.

¹¹ A small quantity of data inputs were received from the Northeast, Far West, and Mid-Atlantic RTTC's. These were combined into the Multi-Region Supplement shown in exhibit 2.

¹² Contained a total of 212 pages: 25 pages for the program plan and 187 pages for the complete appendix.

BASIC SURVEY CONTENT

Company: _____
 Technical Contact Name: _____ Title: _____
 Business Contact Name: _____ Title: _____
 Address: _____
 City: _____ State: _____ Zip: _____
 Phone: _____ Fax: _____ Email: _____
 Number of Employees: _____ Number of Engineers/Scientists: _____
 Company Products: _____
 Annual Sales: \$ _____

Listed below are specific technologies, facilities, expertise, and capabilities of the NASA Lewis Research Center. Please check areas of expertise that may benefit your company's R & D efforts.

- Electronics, Communications, Instrumentation**
- ☐ Image Detection ☐ Image Processing ☐ Microelectronics ☐ Lasers
☐ Neural Networks ☐ Photonics ☐ Expert Systems ☐ Sensors
☐ Telecommunications
- Materials, Structures, Fluids**
- ☐ Coatings ☐ Surface Science ☐ Ceramics ☐ Composites
☐ Polymers ☐ Structural Analysis ☐ Tribology ☐ Microgravity
☐ Computer Simulation ☐ Non-destructive Evaluation
☐ High Performance Metals and Alloys ☐ Computational Fluid Dynamics
- Power, Energy, Thermal**
- ☐ Advance Batteries ☐ Photovoltaics ☐ Heat Dissipation ☐ Heat Transport
☐ Alternate Energy Technologies ☐ Energy/Power Conversion
☐ Power Management and Distribution ☐ Power Conditioning

Please complete the other side of this information sheet so that the "NASA Regional Technology Transfer Center" and the NASA Lewis Research Center will be able to best match your company's company needs with the resources available at NASA.

The following information is to be completed in reference to your company:

LONG TERM RESEARCH AND DEVELOPMENT TOPICS (On what product/process development problems/needs will the company focus R&D resources between 1995 and 2000?):

POTENTIAL JOINT RESEARCH TOPICS WITH NASA (Which elements of the R&D topics could benefit from cooperative research with NASA scientists and engineers? Where might NASA technology help?):

ESTIMATED IMPACT/BENEFIT (How will the above research, if successful, would benefit your company and make it more competitive in the marketplace?):

TOTAL EXPECTED PAST & FUTURE \$ INVESTMENT IN THE R&D TOPIC(S):
☐ \$0-\$50K ☐ \$50K-100K ☐ \$100K-500K ☐ \$500K-1 Million ☐ \$1 Million+

Exhibit 1: Basic survey content used by several NASA RTTC's. Companies were furnished with information about Lewis capabilities to increase the "match potential."

**NASA Lewis
Commercial Technology
(CommTech)
Consultants Program**

**NASA Lewis
Commercial Technology
(CommTech)
Consultants Program**

**NASA Lewis
Commercial Technology
(CommTech)
Consultants Program**

Program Plan and Solicitation

(To All NASA Lewis Scientists and Engineers)

http://nash.larc.nasa.gov/commtech/CommTechProgram_plan.ppt

March 14, 1995

External Programs Directorate
Office of Interagency and Industry Programs
Technology Utilization Office

For Internal NASA Lewis Use Only

Appendix B1

Mid-Continental Region

(Company Completion)

<http://nash.larc.nasa.gov/commtech/CommTechAppendixB1.ppt>

March 14, 1995

External Programs Directorate
Office of Interagency and Industry Programs
Technology Utilization Office

To be used in conjunction with
Appendix B0

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Appendix B2

Southeastern Region

(Company Completion)

<http://nash.larc.nasa.gov/commtech/CommTechAppendixB2.ppt>

March 14, 1995

External Programs Directorate
Office of Interagency and Industry Programs
Technology Utilization Office

To be used in conjunction with
Appendix B0

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**NASA Lewis
Commercial Technology
(CommTech)
Consultants Program**

**NASA Lewis
Commercial Technology
(CommTech)
Consultants Program**

Appendix B3

Mid-Western Region

(Company Completion)

<http://nash.larc.nasa.gov/commtech/CommTechAppendixB3.ppt>

March 14, 1995

External Programs Directorate
Office of Interagency and Industry Programs
Technology Utilization Office

To be used in conjunction with
Appendix B0

For Internal NASA Lewis Use Only

Appendix B0

Multi-Region Supplement

(Company Completion)

<http://nash.larc.nasa.gov/commtech/CommTechAppendixB0.ppt>

March 14, 1995

External Programs Directorate
Office of Interagency and Industry Programs
Technology Utilization Office

To be used in conjunction with
Appendices B1, B2, and B3

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Exhibit 2: Cover sheet format used for the Program Plan and Appendix of Company Needs.

Program Implementation - Stage 2

The implementation stage commenced (on March 24, 1995) with an internal (electronic) release¹³ of the program plan (and solicitation) and appendix to all Lewis scientists and engineers.

After receiving the program package in phase I, interested scientists/engineers responded by completing the three part application (exhibit 3). The first part of the application required applicants¹⁴ to choose six¹⁵ companies out of the appendix of company needs. Applicants who were presently supporting companies or had previously worked with companies on their own had the option to enter up to three of those companies (i.e., if they fell into one of CommTech's target industry sectors). As noted previously, the appendix enabled all Lewis scientist and engineers to apply and compete in phase I to be part of an energized and committed assemblage of phase II lead participants. The other two parts of the application gathered additional information to help gauge each applicant's preparedness to participate, and the degree to which he/she might reliably commit time toward completing the objectives of stage 2 - phases II and III, and most importantly phase IV.

In Phase II a virtual technology "marketplace" of potential buyers and sellers was ignited¹⁶. At this point, the choices of companies Lewis S&E's made in phase I became one of the more important factors (among others) for success. The phase II participant's ability to quickly tune into a company's particular (alien) non-aerospace culture, and communicate and follow through effectively was another factor for success. Most importantly, a company's assessment of (and/or ability to assess) the participant's proposed technology/capability match was critical. Even with the maximum six companies to help reduce the odds, it was challenging for most Lewis S&E's to complete phase II.

Each lead phase II participant was armed with market-need information (provided in the appendix) about each of his/her chosen companies. Several participants selected some of the same companies in phase I. It was therefore necessary to incorporate a high degree of inter-participant coordination into phase II. This prevented Lewis S&E's from contacting companies in an awkward, haphazard, or uncoordinated manner. To accomplish this, each participant was informed about the specific company choices of all other participants that happened to coincide with their own. Phase II was subsequently kicked off, and the virtual marketplace of technical-level communications between Lewis S&E's and technical points-of-contact at each company became active.

¹³ Program information package was released via LeRC's internal file transfer protocol - the first use of FTP at Lewis for large-scale (paperless) program information distribution.

¹⁴ During this phase I application process, all applicants were provided with company names and technology needs descriptions - no specific names of technical points-of-contact were given to avoid any premature interaction. Applicants qualified for phase II through the phase I process based mainly on a measure and comparative analysis of the level of commitment and interest contained in their application.

¹⁵ The choice of six companies was an arbitrary figure, neither too few nor too many, and was used to increase the chances for success in phase II. The majority of applicants submitted required six choices, however a few submitted less.

¹⁶ It was originally intended that lead participants would travel and visit high potential companies at some point during their phase II process. However due to the absence of travel funds, only telephone, electronic, and other non-physical means were available. Hence the serendipitous "virtual marketplace" metaphor.

8.2 Part A: Response Application

NAME: _____ ORG: _____ PHONE: _____

A1. In the space provided below, list six (6) companies, you wish to explore in phase II. At least four (4) companies must be from a different geographical region of the U.S. Two approaches are available (refer to section 5.1.1):

- You may list one, two, or three (non-aerospace) companies you have interacted with in the past that are not in appendix B, then choose the remainder from appendices B0, B1, B2 and B3; or
- You may list all six choices from appendices B0, B1, B2, and B3

| REGION | COMPANY CODE NAME (Part A1) | RANKING (Part A2) | COST-RANGE (Part A3) |
|----------------|--------------------------------|----------------------|-------------------------|
| Far West: | _____ | () (-) | |
| Mid-Continent: | _____ | () (-) | |
| South East: | _____ | () (-) | |
| Mid-West: | _____ | () (-) | |
| Mid-Atlantic: | _____ | () (-) | |
| North East: | _____ | () (-) | |
| _____: | _____ | () (-) | |
| _____: | _____ | () (-) | |

A2. Rank (based on your interpretation of each company's appendix B entry) the six companies you listed above by numbering them consecutively "1" through "6", with "1" representing your top choice. Use the space provided above.

A3. For each of your six companies above, select a cost-range estimate below (for phase II and II combined based on appendix B - also refer to sections 5.1.2, 5.1.3, 6.2, and 6.3), then write it in the space shown above in question 1.

- a. \$ K-\$ K b. \$ K-\$ K c. \$ K-\$ K d. _____

8.3 Part B: Response Application

NAME: _____ ORG: _____ PHONE: _____

There are five questions in Part B. These questions are designed to help you begin thinking about companies from their needs perspective prior to making contact. Your best judgement is sought based on the limited information you have seen in appendix B ("I don't know" would not be an appropriate response). Please answer all five questions for each of the six companies you listed in Part A. Type your responses electronically or otherwise as convenient.

Company Code Name: _____

- Why did you select this company?
- What is your interpretation of this company's technology support need?
- Which of your technological capabilities do you expect this company might find most applicable to its stated product/process development needs and why?
- What other two of your technological capabilities do you think the company might find applicable to its product/process development needs and why?
- What kind of support relationship do you think this company might require, and for what duration (in months or years)?

8.4 Part C: Response Application

NAME: _____ ORG: _____ PHONE: _____

Please answer the five questions in Part C with check marks or circles where appropriate.

- As a NASA employee, have you had the opportunity to directly support a non-aerospace company achieve its product/process development objectives?
☐ Yes ☐ No
 (This program is designed to support the inclusion of S&E's who have had little or no experience in dealing with non-aerospace sector companies. Please do not hesitate to respond. The program will be balanced in this area.)
- Indicate whether you are responding as:
☐ An Individual ☐ A Team (refer to section 7.2)
- If you are a team leader please list the names and organization codes of your team members:
 Name: _____ Org: _____
 Name: _____ Org: _____
- How many hours out of a 40 hour week will you commit to this program during each phase (please circle)?
 Phase II: a. 2 hrs b. 2-4 hrs c. 4-8 hrs d. --- hrs
 Phase III: a. 2 hrs b. 2-4 hrs c. 4-8 hrs d. --- hrs
 Phase IV: a. 2 hrs b. 2-4 hrs c. 4-8 hrs d. --- hrs
- If you are not selected to participate in this program with OIIP funding, would you try to participate with funding from your home organization (refer to section 6)?
☐ Yes ☐ No

Approximately how much time in minutes did you take to complete each part of this questionnaire?
 Part A: ___ mins Part B: ___ mins Part C: ___ mins

Exhibit 3: Three-part application as it appeared in the Program Plan.

Phase II participants used the limited information provided in the appendix to understand their companies' needs in order to prepare for an introductory conversation with the respective technical contact points. The aim of this initial conversation was to quickly develop a more in-depth technical understanding of a company's product/process development needs - and vice-versa for the company. The participant (together with his/her technical point-of-contact) used this deeper understanding to make a rapid and accurate assessment of whether his/her particular technology and/or capabilities might match a company's need. Capability demonstrations¹⁷ were provided at a company's request if the lead participant thought the interaction held promise. Contacts were made according to a sequential contact strategy to avoid raising (any company's) expectations that could not be met. Therefore, when a match was found, the participant would cease his/her

¹⁷ A total of \$230K was budgeted to support demonstration objectives in CommTech's three focus industry sectors.

sequential contact process at that point. Further contacts were made only if the lead participant were willing to assume the additional responsibility which would result from the discovery of another match.

Although phase II had a planned duration of 3 months, it was expected that in many cases it would be necessary to extend this phase for an additional 3 months to allow slower-to-develop relationships to coalesce. Similar reasoning was applied to phase III.

After securing a “technical” match between technology need and capability (or demand and supply) discussions shifted to the “business” level. In other words, phase II transitioned into phase III. In phase II, those participants who were fortunate enough to discover a company whose needs matched their capabilities proceeded to phase III. Those who did not, terminated their participation in the program with a clear and measurable effort and contribution to show for it. Phase III ended, on an individual basis, when a formal Space Act Agreement¹⁸ was officially signed by NASA and a particular company. This agreement represented NASA’s legal obligation to deliver specific technologies/support to that company at a specified cost and schedule.

Phase III participants who successfully negotiated and established an (Space Act) agreement transitioned into phase IV.¹⁹ Here, the participant’s ability to deliver on his commitment became critical. The challenge all lead participants faced at this point was incorporating scheduled, non-aerospace support obligations into their “higher priority” aerospace work schedules.

In addition to the success/risk factors mentioned with respect to phase II above, it was well recognized that overall success during stage 2, in particular phase IV, depended largely on the degree of relevance or importance each lead participant’s functional manager attached to non-aerospace interactions. This constituted an additional risk factor which, in several cases, may have negatively impacted the performance and output of stage 2.

¹⁸ Non-contractual relationships established between NASA and private sector entities are defined as Space Act Agreements in accordance with the National Aeronautics and Space Administration Act of 1958.

¹⁹ Phase IV had a planned duration extending through fiscal year 1997.

Results of Implementation Phases

Phase I: Response and Participant Selection

Twenty-six (26) scientists/engineers²⁰ responded to the phase I solicitation. Of these, 16 applied as individuals and 10 as teams. In addition, 9 applicants had experience in non-aerospace technology transfer while 17 had no experience. These applicants selected a total of 73 companies to explore in phase II of which 58 (or 79%) were chosen from the appendix,²¹ and 15 (21%) were included by some experienced applicants. Figure 3 provides additional aggregate information on industry sectors and regional sources.

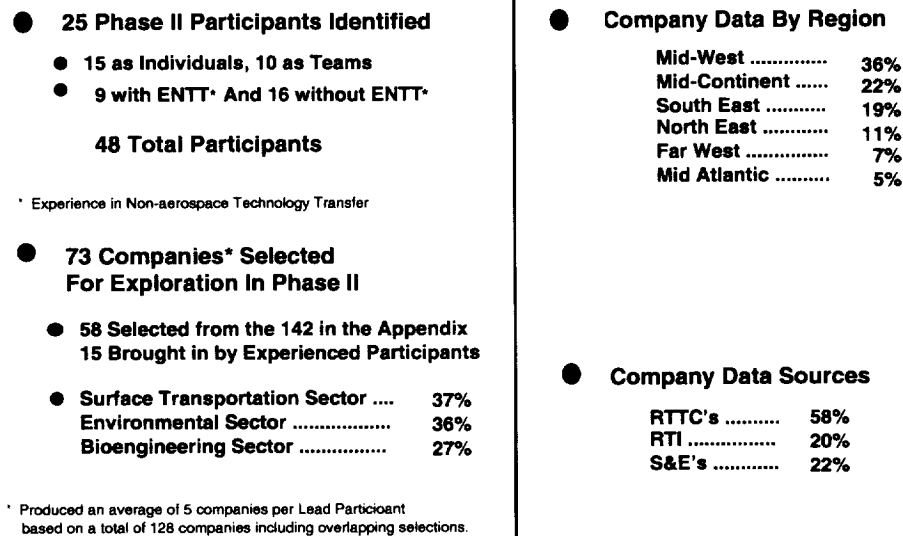


Figure 3: Summary of Phase I aggregate input/output results

Figure 4 portrays the virtual team arrangement tool which was used to coordinate and display an evolutionary “cross-section” of phase II activities at any point in time. This tool enabled coordination and tracking of the dynamic phase II, interactive marketplace process (which was activated at the end of phase I). Lead participants (and their team members) formed ready-to-engage points-of-contact for their chosen companies grouped around the rim. The program manager was available to coordinate and provide strategic guidance as needed.

²⁰ One applicant applied twice making the actual number of applications 26.

²¹ This appendix contained 142 company technology needs profiles, and was produced primarily to enable applicants without any previous non-aerospace technology experience to participate (and compete) in the phase I process.

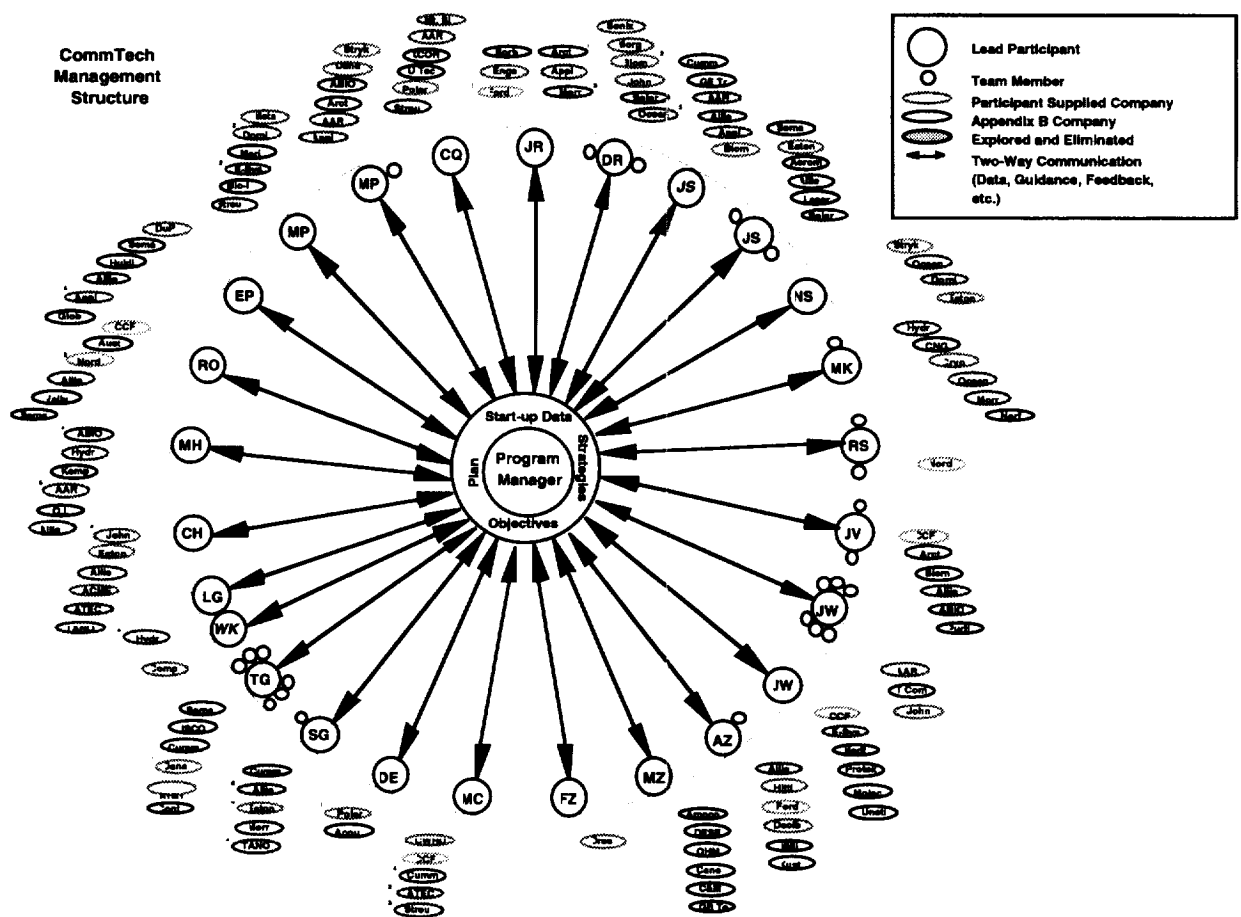


Figure 4: Phase II virtual start-up configuration. Selected lead participants were arrayed outward to illustrate an appropriate outreach posture with respect to the companies they chose. The program manager was centrally positioned to interface directly each lead participant and provide strategic and other facilitative support.

Phase II: Company Relationship Exploration

The mid-phase II (July 17, 1995) evolutionary status of the phase II virtual marketplace is shown in figure 5. This picture was assembled about one month before the 3-month phase II/III transition milestone (refer to figure 2). By this date, some participants had already completed their phase II explorations.

As shown, several (shaded) companies had been explored and eliminated by the respective lead participants. Numerous (short) links are shown extending between each participant and their respective company symbols. This indicated the establishment of a two-way communication (voice mail messages were not considered valid communications) with those specific companies. Once communications were established with a company, it was then allowed to assume significant control over the pace, quality and final disposition of the interaction. A shaded company symbol indicated that the company had been explored and eliminated due to the lack a need/capability match. This was jointly determined through technical interchanges - as explained previously.

CommTech Phase II
S&E Initiated Interactions
July 17, 1995

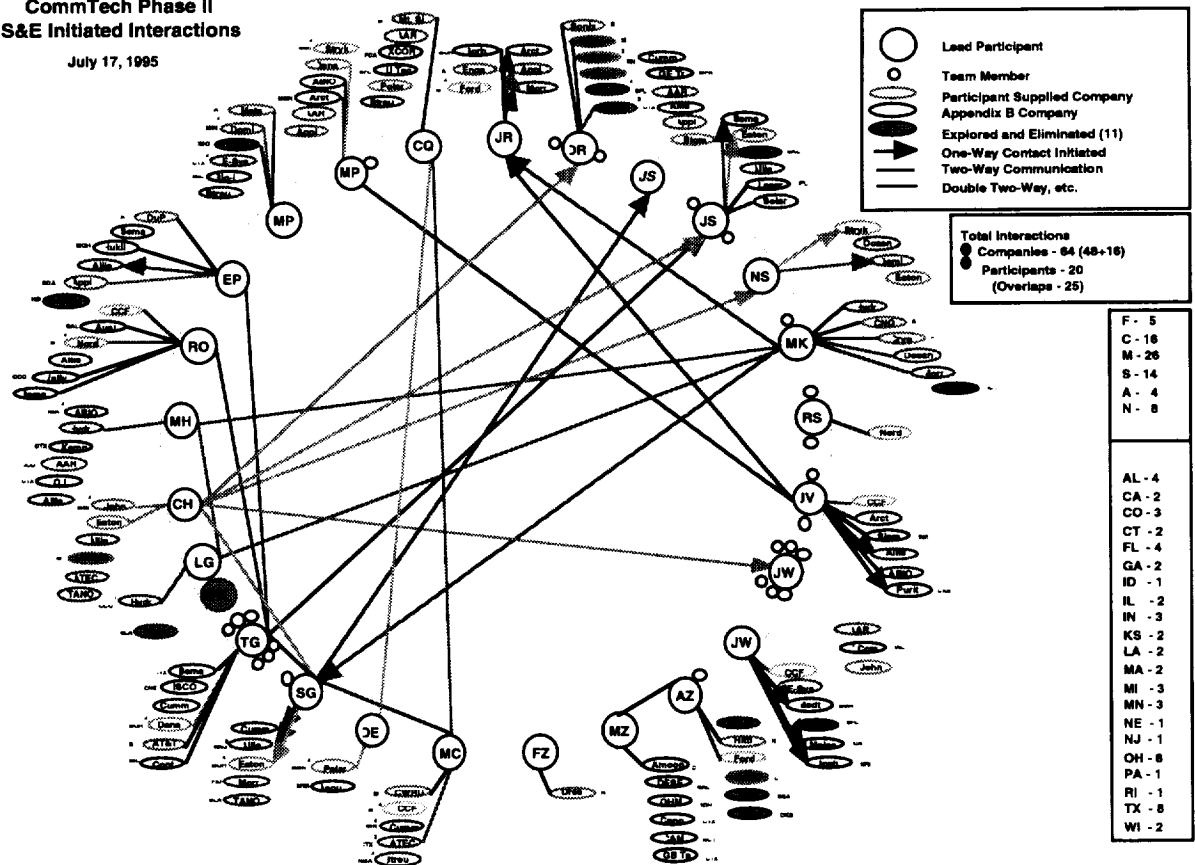


Figure 5: Virtual marketplace activity near the planned 3-month Phase II to Phase III transition point. Company-participant and inter-participant communication links are shown.

Several (longer) links are also shown connecting various participants. This indicated that those participants who had selected the same company(ies) for different reasons were coordinating their interactions with those companies (inter-participant coordination interactions peaked around July 7, 1996). A shaded participant symbol indicated that that participant's activities had ceased after all his/her companies had been explored without finding at least one need/capability match. In other words, the companies were all contacted sequentially, and each indicated no current (or no further) need for the participant's capabilities and offer of support.

Figure 6 portrays the cumulative totals and the various rates at which the scientists and engineers initiated their company interactions during phase II. As shown, 125 out of a possible maximum of 128 (or 98%) company interactions (the total count resulting from the overlapping selections of the same company(ies) by different participants) were recorded by August 7, 1995. At the end of phase II, eleven (11) lead participants²² had successfully established relationships which could be transitioned into phase III.

²² At the time this report was written only one newly admitted lead participant remained active in a phase II mode.

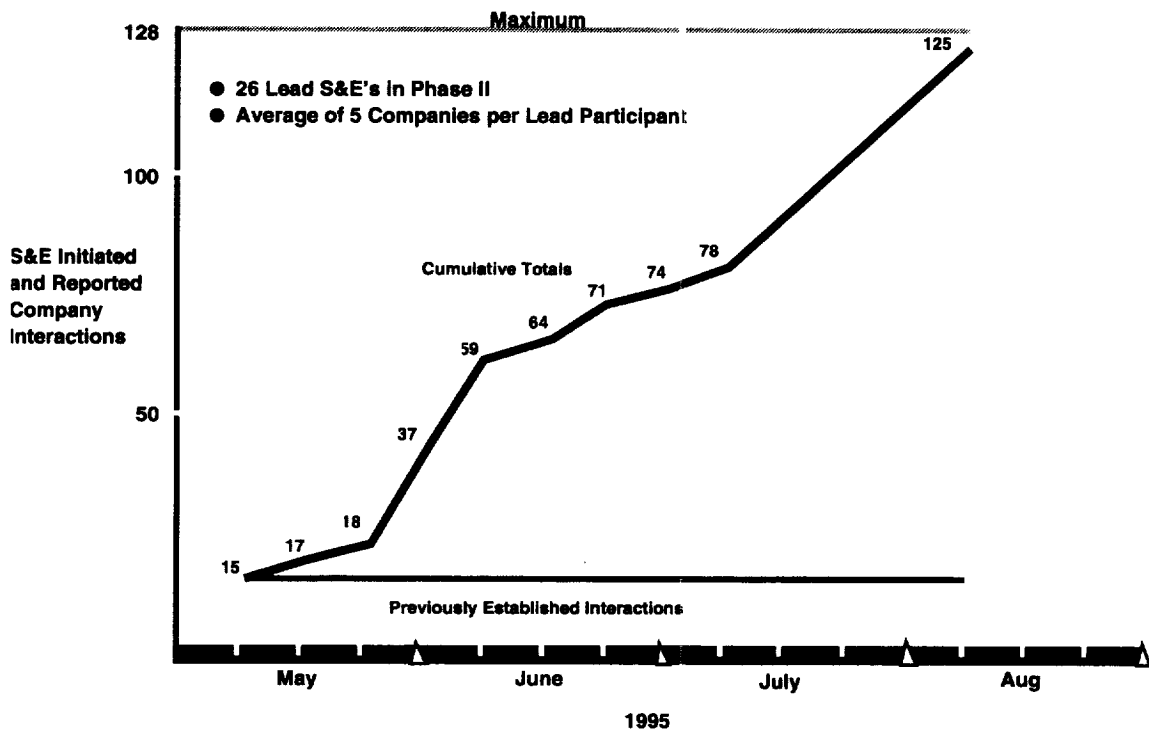


Figure 6: A measurement of the amount of effort expended, and an indication of the rate at which the effort was expended during phase II.

Phase III: Relationship Definition and Agreement

The development and completion of technical-level discussions varied widely from participant to participant. As a result, the transition from phase II to phase III was managed on a case-by-case basis since each participant progressed at a different rate due to differences in company (organizational) interface structures. Out of the initial 26 lead participants who entered phase II, and the 11 who progressed to phase III, four Space Act Agreements were established. Basically, 1 agreement was generated for every 6.5 participants that entered the program in phase I. These agreements were as follows:

- Sonix, Inc. (Cooperative) - Development and Commercialization of Ultrasonic Thickness and Surface Profilometry;
- East Ohio Gas Company (Reimbursable) - Underground Liquid Natural Gas Tank Test and Analysis;
- Cleveland Clinic Foundation (Reimbursable, Interagency - Funded by the National Institutes of Health) - Pump Design and Analysis Services for the Innovative Ventricular Assist System (IVAS) study; and
- Cleveland Clinic Foundation (Non-reimbursable) - Liquid Crystal Shutter Glasses for the Diagnosis of Functional Visual Loss and Malingering.

In addition to the four above, two additional agreements were included in the phase III count:

- Essential Research, Inc. (Reimbursable)²³ - Development of Optoelectronics Devices, Solar Cells and Related Technology;
- Deere & Company Technical Center (Reimbursable)²⁴ - Ammonia Distribution System Characterization.

The Essential Research, Inc., agreement was not negotiated within the CommTech framework but was admitted into the program as a phase IV project. The Deere & Company agreement represented the last late (lead participant) entry into the program prior to preparing this report. This agreement was developed and finalized according to CommTech procedures.

Although CommTech's main target was "for-profit" entities, two lead participants submitted the non-profit Cleveland Clinic Foundation as one of their six company choices. This occurred because of NASA Lewis' special emphasis on fostering relationships between its scientists and engineers and local Cleveland-based companies - especially the world renown CCF. However, in order to be measured as a CommTech success, the NASA/CCF partnerships would have to involve for-profit partners at some point. In other words, the CommTech program's primary focus remained profit-driven companies that needed NASA Lewis' technologies and capabilities, and were able to produce and market new products and/or processes.

Phase IV: Agreement Implementation and Execution

As mentioned previously, it was expected that a large fraction of lead participants would not progress from phase II to phase III. For that matter, even fewer were expected to progress from phase III to phase IV. Figure 7 shows an estimate of the present, overall relative progress of all participating Lewis S&E's along the three-phased continuum. It must be emphasized that the lack of success in phases II or III did not constitute failure. That is why one of the critical measures used in recording CommTech's overall performance was the effort expended by all participants during phases II and III.

Of the 6 phase III agreements highlighted earlier, 5 are currently on-going projects. Four of these projects originated from the initial phase I participant group. These projects are being executed according to their respective phase IV schedules. At the time this paper was written, three agreements/projects had been completed: Sonix, Inc.; East Ohio Gas; and Cleveland Clinic (non-reimbursable). Commercialization results are not yet available for these activities.

Performance Measurement Technique Formulation

As indicated earlier, tracking and measurement techniques would be devised in phase IV. In that regard, the private/public investment²⁵ ratio was formulated to provide a future means of providing cycle to cycle performance comparisons. It was found that it would be useful for the CommTech program to have a single overall program performance metric that could be used as a general performance indicator or index.

²³ The ERI agreement was established prior to CommTech. The lead Lewis engineer was granted entry into the program in a phase IV capacity. This relationship currently represents the most promising for-profit relationship in the CommTech portfolio.

²⁴ The agreement, which was initiated by John Deere Des Moines Works, was subsequently transferred to Deere & Company Technical Center for implementation in the Fall of 1998.

²⁵ The author considers the terms "investment" and "cost" interchangeable in the context of technology transfer and commercialization.

The private/public investment ratio (PPIR) is written as:

$$PPIR = I_{\text{Private}} / I_{\text{Public}}$$

where:

I_{Private} = The total “private dollar investment” in one or more technology transfer and commercialization objectives;

and

I_{Public} = The total “public dollar investment” in one or more technology transfer objectives.

If the process of demand driven technology transfer and is considered a “production” process, then I_{Private} and I_{Public} can perhaps be determined from the following two equations²⁶ (the specific functions represented by each term in each equation, along with the relevant or associated stage 2 phases, are given in parentheses below):

$$I_{\text{Private}} = A + f_l H_l W_l \sum L_h + f_e H_e W_e \sum E_i + f_p H_p W_p \sum P_j + f_m H_m W_m \sum M_k$$

$$\{ I_{\text{Private}} = \text{Transfer (phase III)} + \text{Transfer (phase III)} + \text{Transfer (phase II/IV)} + \text{Transfer \& Commercialization (phase IV)} + \text{Commercialization (post phase IV)} \}$$

and,

$$I_{\text{Public}} = D + f_m H_m W_m \sum M_k + f_e H_e W_e \sum E_i + f_l H_l W_l \sum L_h$$

$$\{ I_{\text{Public}} = \text{Transfer (phase II)} + \text{Transfer (stage I/phase I)} + \text{Transfer (phase II)} + \text{Transfer (phase III)} \}$$

where the stated “labor” and “capital” “factors of production” and their associated “price” determinants are described by:

A = The private dollar amount committed to fund an established (Reimbursable or Cooperative) Space Act Agreement;

D = The public dollar amount expended to provide a capability demonstration to a particular company;

$f_{(l, e, p, \text{ or } m)}$ = Inflation factors to adjust each term;

$H_{(l, e, p, \text{ or } m)}$ = The number of hours needed to perform each of the key functions, respectively;

$W_{(l, e, p, \text{ or } m)}$ = The hourly wage rates of each respective functional area (as a function of government, company or industry origin);

²⁶ The two equations are derived from the economic theory of production. The validity of this approach remains to be demonstrated in practice. This will depend on whether the necessary input data will actually be provided by (any or all) participating companies.

L_n = The number of legal personnel needed to establish the technology transfer agreement;

E_i = The number of engineering personnel needed to demonstrate and/or transfer the technology (public and private); and/or to incorporate the transferred technology into a new or existing product design (private);

P_j = The number of production personnel needed to actually produce the new or modified product (private); and

M_k = The number of marketing personnel needed to promote and introduce CommTech (public); and, position and develop a promotion and pricing strategy for the new/modified product (private).

{Note: It was beyond the scope of the CommTech program first cycle objectives to gather all the above investment data. As a result, a PPIR based on the simple “A/D” approximation (see Table 1), was determined only to serve as a rough point of departure or baseline. In the future, however, detailed, individual and aggregate PPIR’s would need to be estimated during Phase III, and then adjusted and finalized during Phase IV.

It was understood that companies generally tended not to track unpatented/unlicensed technology transfer from source to end product application and commercialization. As a result, a company’s technology transfer and commercialization process (cost) data tend to dissipate. Because of this, the process data (above) would have to be acquired from a company during each relevant phase (II, III, and IV). }

Results Summary

Table 1 displays a summary of the metrics resulting from each of the phases in stage 2. As noted previously, the initial 26 phase II participants produced a participant/agreement ratio of 6.5 (based on 4 agreements), or 2.2 with respect to phase III (based on 6 agreements). For all 6 phase III agreements, the cost was \$22K per agreement, or \$26K per project, with respect to the total \$130K for demonstration expenditures.

The private/public investment ratio (PPIR) as described above was formulated as a key parameter or metric by which CommTech could gauge and compare performance over time. This ratio was designed to be a measure of the aggregate efficiency of the program - the higher the PPIR, the greater the efficiency. A detailed, first CommTech cycle PPIR, however, could not be determined since the methodology was developed as an output of this first CommTech cycle for application with future cycles. Instead, a simplified approximation is calculated and given below as a rough performance measure and basis for comparison with future cycles.

| | | Lewis ¹ Participants | Outreach Effort | Companies | Public Investment (D) | Private ⁵ Investment (A) | Private/Public ⁶ Investment Ratio | Signed ⁷ Agreements | Projects ⁸ | Participant/ Agreement Ratio | Participant/ Project Ratio | Product/Process Applications | Commercialization: Impact |
|---------|-----------|------------------------------------|--------------------|-----------|--------------------------|----------------------------------------|-------------------------------------------------|-----------------------------------|-----------------------|---------------------------------|-------------------------------|---------------------------------|------------------------------|
| Stage 1 | | | | 256 | \$80K ⁴ | | | | | | | | |
| Stage 2 | Phase I | Open ² | | 142 | | | | | | | | | |
| | Phase II | 26 | 125 | 73 | \$70K | | | | | 6.5 ⁹ | 6.5 ⁹ | | |
| | Phase III | 13 ³ | | 16 | \$60K | | | 6 | | 2.2 | 2.6 | | |
| | Phase IV | 5 | | 5 | | \$200K | 0.95 | | 5 | | 1 | TBD | TBD |

1 Includes 3 new participants who entered the program in FY96.

2 Program was open to all NASA Lewis S&E's - 26 applications were submitted.

3 Eleven (11) from initial 26 phase II participants plus 2 later additions.

4 Market research cost estimate (NASA Headquarters (RTTC's & RTI) contract/task obligation).

5 Includes estimate on all fully negotiated, signed and unsigned FY97 Agreements.

6 Simplified estimate shown based on Private Investment/Public Investment data in Table.

7 Four (4) agreements were generated by the initial 26 phase II participants.

8 Includes estimate on all started and expected FY97 projects.

9 Based on 4 agreements (see note #7).

TBD: To be determined

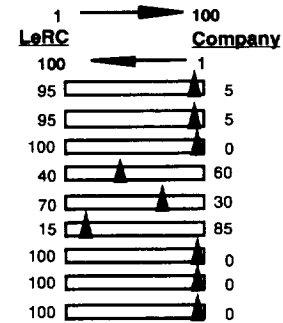
Table 1: First CommTech cycle Stage 2 results summary.

Program Success Factors

Several key (CommTech) success factors were identified. Some were within the program's ability to influence and control, and others were not. The success factors are meant to indicate what factors were responsible for producing the results shown above. At the same time, they also indicate what overall factors need to be considered and mitigated if possible in order to improve the chances for better performance in future cycles. The main success (or risk) factors for each stage are presented in figure 7 below. The scales to the right provide a quantitative estimate or measure of the degree of control Lewis (as a whole) had over each success factor, relative to that of any potential client company. The accompanying table 2 shows the degree of (process) control for each stage and phase of the program. Overall, the control fraction split was Lewis, 76 %, and the company, 24 %. In other words, from the Lewis standpoint, the CommTech approach contains about a 24% (inherent) risk, due to factors which were wholly or partly within the control of the other party.

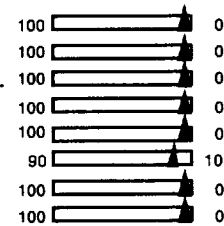
Stage 1:

1. Market research source(s) effectiveness.
2. Company awareness of Lewis' availability.
3. Timing.
4. Level of market (industry/company) demand.
5. Company perception of need/capability synergy.
6. Company responsiveness.
7. Program management degree and quality of engagement.
8. Agency/Center policy environment support.
9. Functional management support.



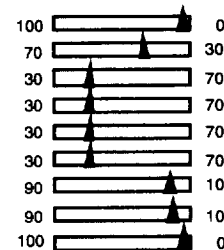
Stage 2/phase I:

1. Level of S&E morale.
2. Timing.
3. S&E's perception of Agency, Center and/or functional management interest.
4. S&E's interpretation of value-added.
5. Type of distractions/threats in the S&E environment.
6. S&E's level of attention and interest.
7. Program plan quality and clarity.
8. Application forms quality and effectiveness.



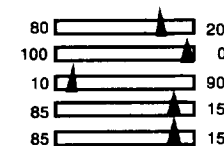
Stage 2/phase II:

1. Lead S&E ability to adapt and communicate with different companies.
2. Lead S&E commitment.
3. Time lapse between receipt of survey results and delivery to Lewis S&E's.
4. Company interest.
5. Company willingness to give information.
6. Company ability to assess Lewis technology/capability applicability.
7. Program management strategic guidance.
8. Functional management support.
9. Availability of demonstration funds.



Stage 2/phase III:

1. Lead S&E's schedule flexibility.
2. Lead S&E's ability to plan effectively.
3. Company schedule flexibility.
4. Program management negotiations support.
5. Functional management support.



Stage 2/phase IV:

1. Lead S&E's ability to deliver - per agreed schedule and cost.
2. Company product/process development or market commitment.
3. Functional management support.
4. Program management support.

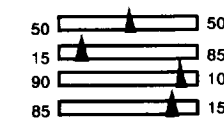


Figure 7: Success factors and relative degree of control or risk indicators

| | | Degree of Control - LeRC % | Degree of Control - Company % |
|---------|-----------|-------------------------------|----------------------------------|
| Overall | | 76 | 24 |
| Stage 1 | | 79 | 21 |
| Stage 2 | Phase I | 99 | 1 |
| | Phase II | 63 | 37 |
| | Phase III | 72 | 28 |
| | Phase IV | 60 | 40 |

Table 2: Summary of relative degree of process control or risk.

Conclusions and Recommendations

The results in this paper demonstrated that the process of technology transfer and commercialization does not happen overnight. Instead, it requires an equal, clear and sustained long term commitment underpinning a palpable and defined interest on both the demand and supply sides of any potential relationship. In general, both the quality of the process output and the overall success potential depend mainly on the satisfaction of this condition - among other considerations - in addition to a keen appreciation of the relative degree of control of the CommTech process.

Basically, the CommTech methodology was applied in a diverse R&D organization with a sizable scientific and engineering population. The limits of the methodology were not explored. The first cycle was developed, introduced and managed by one program manager. Given this, it is possible that a larger scale of input and output can be produced and successfully managed with the proper application of additional program management resources. Certain activities in Stage 1 and Stage 2 (phase II and III, in particular) might benefit from more specialized and focused support.

The goal of demonstrating the potential advantages of a "low-cost/high productivity" demand-driven technology transfer model was accomplished - along with all corresponding objectives. This can be seen in the results summarized in Table 1. The CommTech methodology demonstrated the potential to be an efficient, productive, measurable, and manageable process/model. Nevertheless, the potential for improvement is very evident. In addition, the results indicated that a pro-active, demand-driven approach might produce improved performance and more traceable results than traditional supply-driven methods. Although this was not conclusive, it was clear that the overall performance of a technology transfer program can be maximized if it was appropriately balanced around a mix of both pro-active, demand- and supply-driven components.

With regard to improved performance, the author thinks that the controllable success factors mentioned earlier need to be identified and adjusted. Of particular importance is the matter of (potential) non-aerospace clients' (early) awareness of Lewis' availability. It is possible that, given more (program support) lead time, combined with more information about CommTech objectives, the NASA Technology Transfer Network might provide more effective support in this area. In addition, the productivity of the CommTech approach might be enhanced if a travel budget were available for lead S&E's to visit with select companies and obtain a face-to-face understanding of their respective problems or needs. This additional public cost/investment expenditure would probably result in higher quality interactions which might in turn produce a better, more productive relationships and agreements.

It was also observed that the ability to employ the CommTech approach might be enhanced if public funds could be allocated to demonstrate technologies and capabilities, and be treated more as "patient" (public) capital. This would allow these funds to be invested in establishing technology transfer relationships instead of being forced to conform to a traditional financial management protocol (commit/obligate/cost) designed to ensure the efficiency of government-to-industry procurements.

The traditional government procurement system places an unnatural pressure on the public side of the technology transfer relationship building process. In other words, the present financial management system needs to recognize that the rate of relationship development is under private (and not public) sector control. Given this fact, it would clearly be better if public sector technology transfer expenditures could be made to operate more like strategic, long-term economic investments - instead of standard procurement actions. CommTech - and technology transfer programs in general - would better thrive and exhibit increased efficiency and productivity in a financial management environment which was more accommodating to the special characteristics of technology transfer.

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